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Cover: The carabid beetle genus *Nurus* has about 10 large, heavy-bodied species which occur along the eastern seaboard of Australia from northern NSW to north Qld. They live in spiral burrows which they excavate with their mandibles. Prey is ambushed from the burrow entrance at night. Females brood their eggs and first instar larvae in the burrow. *Nurus brevis* Motschulsky, 1865 occurs near Lismore and is listed as rare and endangered by NSW legislation. Illustration by Geoff Thompson.

CORRECTING ERRONEOUS LARVAL FOOD PLANT RECORDS: THE CASE OF *HYPOCHRYSOPS BYZOS* (BOISDUVAL) (LEPIDOPTERA: LYCAENIDAE)

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Abstract

The larval food plant for *Hypochrysops byzos* (Boisduval) on Mt Warning, in northern New South Wales, is corrected from *Astrotricha longifolia* (Araliaceae) to *Rulingia salviifolia* (Sterculiaceae). The importance of removing erroneous records from the literature is discussed.

Introduction

Eastwood (1997) recorded *Astrotricha longifolia* Benth. (Araliaceae) as a larval food plant for the lycaenid butterfly *Hypochrysops byzos* (Boisduval) on the upper slopes of Mt Warning National Park in northern New South Wales. Doubts were raised subsequently regarding the authenticity of this record, particularly since *A. longifolia* was not known to occur on Mt Warning. Furthermore, *H. byzos* usually feeds on *Pomaderris* species (Rhamnaceae) and, since *Pomaderris argyrophylla* N.A.Wakef. occurs on the upper slopes of Mt Warning and its leaves resemble those of *Astrotricha* spp., it was thought that this may be the correct larval food plant. As a result of the uncertainty, Braby (2000) did not include *A. longifolia* as a larval food plant for *H. byzos*, suggesting it was likely to be a misidentification. The purpose of this paper is to document the correct larval food plant and comment on the importance of removing erroneous records from the literature.

Observations

The correct larval food plant for *H. byzos* on Mt Warning is *Rulingia salviifolia* (Hook. ex Steetz) Benth. (Sterculiaceae). This plant grows in sandy or skeletal soil and is usually found in the understorey of eucalypt woodland, but appears to thrive in relatively exposed conditions on the summit of Mt Warning. Its distribution is on coastal mountains from Mt Warning in the south to Mt Byron (north-west of Brisbane) in the north (Queensland Herbarium records). The Mt Warning ecotype is typical of the species, except that the indumentum of the upper leaf surface is relatively sparse, resulting in green or grey-green appearance, rather than the usual grey or silvery-grey.

The original (incorrect) identification in 1996 was based on a sprig of fresh leaves; however, this amended record was determined from a flowering pressed specimen, highlighting the importance of reproductive structures for accurate plant identification. This voucher specimen is to be lodged at the Queensland Herbarium. Elsewhere, *H. byzos* has been recorded feeding on another member of Sterculiaceae, *viz. Commersonia fraseri* J. Gay, while the closely related *H. pythias* C. & R. Felder feeds on the congeneric *C. bartramia* (L.) Merr. (Braby 2000).

Discussion

It is important that erroneous records, when discovered, are formally corrected in the literature so that incorrect information is not perpetuated or used to effect misleading conclusions. Accurate larval food plant data are important from an evolutionary perspective when interpreting plesiomorphic or apomorphic character states, host shifts, or phylogeographic patterns. For example, it is likely that *H. pythias* is ancestral to *H. byzos*, since the former has a wider distribution, a greater number of subspecies and a more closely related sister species, *H. gemminatus* Sands (Sands 1986). Examination of larval food plant records in relation to this hypothetical arrangement suggests that the speciation of *H. byzos* may have coincided with a host shift from Sterculiaceae to Rhamnaceae, and that the population of *H. byzos* on Mt Warning may therefore represent a reversion to the ancestral larval food plant. The interpretation of such a character reversion would be incompatible with the record of *A. longifolia.* Accurate records of plant predator fauna also may provide useful phytogeographic data or be important for determining potential biological control agents. Finally, larval food plant records may be used as predictive tools when assessing a species' geographical distribution. Hence, accurate larval host plant information is essential for the development of informed conservation strategies for threatened species.

Acknowledgements

We thank Glenn Leiper, Frank Jordan and John St. Ledger Moss for their interest and helpful advice.

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FEEDING BY *KAHAONO* LEAFHOPPERS IN SILKEN SHELTERS (HEMIPTERA: CICADELLIDAE: TYPHLOCYBINAE: DIKRANEURINI)

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Abstract

Adults and nymphs of the leafhopper *Kahaono montana* Evans have been observed feeding beneath a silken web or tent attached to the host leaf. Feeding by the leafhoppers is confined to the limits of the tent. Beads of liquid excrement catch on the tent to form a layer that may provide camouflage over the feeding insects. Possible benefits of this feeding behaviour are discussed.

Introduction

Cicadellid leafhoppers of the subfamily Typhlocybinae are parenchyma feeders and feed almost exclusively on the epidermal cells of leaves. Of the six typhlocybine tribes, four are known to occur in Australia (Fletcher and Larivière 2001). The tribe Dikraneurini is represented in Australia by four genera, three of which are endemic and exclusively restricted to host plants in the genus *Eucalyptus* (Myrtaceae). *Aneono* Kirkaldy, *Kahaono* Kirkaldy and *Dziwneono* Dworakowska are all flattened dorsoventrally and adapted to fit closely to the vertical leaves typical of plants in this genus. Many of the species in these genera are brightly coloured with red and green being common.

Observations

In July and August 1987, individuals of *Kahaono montana* Evans (Fig. 1) were found at Seven Hills, in the western suburbs of Sydney, feeding under circular structures or tents made of fine silken webbing fastened to the leaf around the perimeter of the structure. The host tree was an unidentified species of *Eucalyptus*. This observation was first reported by Day and Fletcher (1994), who provided little detail. Adults and nymphs, as well as cast skins, were found under the web and feeding damage caused by the leafhoppers was restricted to the area of the leaf covered by the tent (Fig. 2). The tent was decorated by small globules of excrement presumably ejected by the leafhoppers as they fed and these turned black through the growth of sooty moulds (visible in Fig. 1). In some cases, the amount of excrement on the web was sufficient for the globules to run together to form a continuous covering over the leafhoppers (Fig. 4).

In February 2001, further observations of the same species of leafhopper, feeding under similar structures, were made at two State Forests of NSW eucalyptus plantations on the north coast of New South Wales. At the first plantation, located near Dorrigo, the species was feeding on 3 year old *Eucalyptus dunnii* Maiden, while at the second plantation, near Urbenville,

the host species was *E. grandis* Hill ex Maiden. Feeding damage by the leafhoppers was again restricted to the leaf area covered by the tents, which were always found on the abaxial surface of the leaf. The damage symptoms were observed as chlorotic patches which then darkened to a reddish hue as feeding continued. In all cases, globules of excrement, discoloured to black, were caught in the webbing. A tent from the Dorrigo population is shown in Fig. 3. The number of trees affected by the leafhopper was small and damage was restricted to isolated patches within the plantations.

Discussion

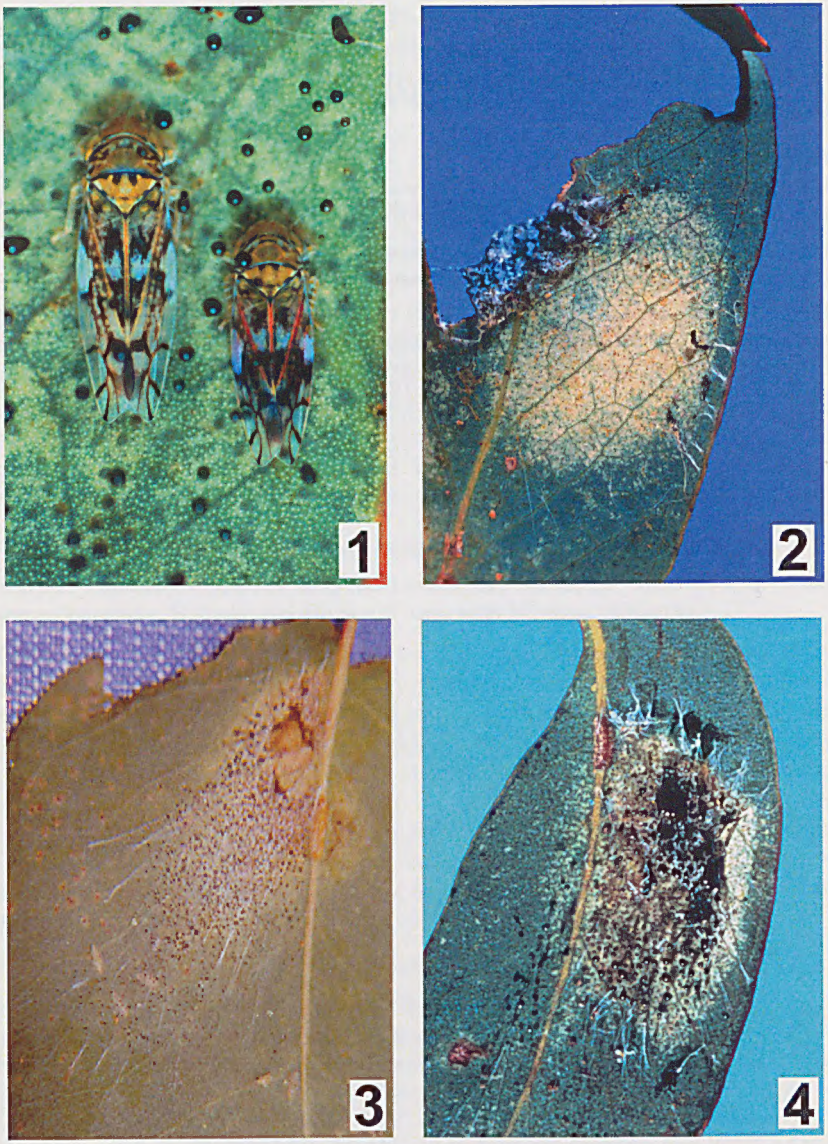
This behaviour has not been observed in other species of leafhoppers. Even other species of *Kahaono* appear to have more typical feeding behaviour. In March 1997, large numbers of *K. wallacei* Evans were found feeding on eucalypt leaves in Orange Botanic Gardens (Fletcher, unpubl. obs.). The large numbers of leafhoppers caused sufficient discolouration of both surfaces of the leaves to change the appearance of the tree dramatically but no evidence of tents was observed on the damaged leaves. The feeding insects were distributed generally over the abaxial leaf surface and resulting feeding damage was not restricted in the manner shown for *K. montana* in Fig. 2.

It is unknown whether the tent is produced by the leafhoppers themselves or is a product of some other organism which has been utilised by the leafhoppers. However, observations of a number of tents showed that the only inhabitants were leafhoppers. This contrasts with the observation by Bourgoin and Wilson (1992) of a planthopper, *Myndus chazeauxi* Bourgoin & Wilson (Hemiptera: Cixiidae), sheltering during the day in silken shelters in leaflet hollows of palm fronds that were shared with the clubionid spiders that had created the shelters. Other hemipteran groups use protective structures to cover the feeding nymphs and, in some cases, adults. The lerps produced by many Psyllidae are secreted by the nymphs for their protection and many coccoids also produce a protective covering. However, these coverings are waxy or chitinous in substance, whereas the tents of *K. montana* are clearly silken and similar in texture to fine spiderweb.

It is important to note that the same species has been observed feeding under such a structure on two separate occasions, 14 years apart, in three quite distinct localities, while other species of the same genus have not been associated with such behaviour. Since the feeding of the leafhoppers is clearly restricted to the area under the tent only (Fig. 2), there is a definite association between the leafhopper and the tent. Possible benefits of feeding under such a structure could include camouflage, protection from parasites and predators or protection from dehydration.

Acknowledgements

The authors thank Alan Krikman (Seven Hills, Sydney) and Darren Waterson (State Forests of NSW) for bringing these specimens to our attention.



Figs 1-4. *Kahaono montana* leafhoppers and feeding tents. (1) Adult female (left) and male feeding under globules of blackened excrement suspended on the tent; (2) Leaf with tent folded back (to top left) to reveal feeding damage. Anchor points from the tent can be seen to the right of the feeding area; (3) Leaf of *Eucalyptus dunnii* near Dorrigo with webbing tent covering nymphs; (4) Tent on gumleaf with continuous covering of excremental material.

The photographs were taken by Lowan Turton (NSW Agriculture) [Figs 1, 2, 4] and Angus Carnegie (State Forests of NSW) [Fig. 3]. Helpful comments on the manuscript were provided by Angus Carnegie and John Macdonald (NSW Agriculture).

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TWO GENERA OF MITES NEW TO THE AUSTRALIAN FAUNA (ACARI: ACARIDAE)

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Abstract

Mycetoglyphus fungivorus Oudemans is recorded from Australia for the first time. This species is found in decaying organic matter but is also capable of damaging crop plants. *Kuzinia laevis* (Dujardin) is recorded from Australia and New Zealand, in association with the introduced bumble bee *Bombus terrestris* (L.), where it feeds on pollen.

Introduction

The documented Australian fauna of the mite family Acaridae includes 17 genera (Halliday 1998). Recent study of the Australian fauna has revealed the presence in collections of specimens of a further two genera. The purpose of this note is to provide details of these collections, so that the genera concerned can be included in a larger study of the Australian Astigmata that is currently in progress.

Mycetoglyphus fungivorus Oudemans

Material examined. SOUTH AUSTRALIA: 2 ♀♀, Nuriootpa, 12.x.1979, in worm rearing container, B. Linke coll. (in South Australian Museum, Adelaide).

Comments. Mycetoglyphus fungivorus is a saprophytic mite that has been found in mushroom culture, decaying vegetables, decaying wood debris, beneath stacks of hay and straw and in the nests of moles and ants (Hughes 1976, Kazhdaya 1996). It also appears to be capable of occasionally damaging crop plants (Nakao 1989). It has not been recorded from Australia before, with previous records from England, USA, South Africa, former USSR, Europe (Zakhvatkin 1941, Hughes 1976), China (Li 1999) and Japan (Nakao 1989). The species may be recognised according to the description and illustrations in Hughes (1976). *M. fungivorus* is now recorded from Australia on the basis of the specimens detailed above.

Kuzinia laevis (Dujardin)

(Fig. 1)

Material examined. TASMANIA: 14 deutonymphs, North Hobart, 15.iii.1994, on bumble bee, T. D. Semmens coll. (in Australian National Insect Collection, ANIC); 10 ♀♀, 3 ♂♂, Warra Long Term Ecological Research Site (Arve Valley, west of Geeveston), 12.iv.2001, R. Buttermore coll. (ANIC). NEW ZEALAND. 3 ♀♀, Hastings, Zonda Resources Ltd., 7.i.2000, in bumble bee breeding colonies, L. Rako coll. (in New Zealand Arthropod Collection, Auckland). POLAND. 4 ♀♀, 2 ♂♂, Poznan, 13.iii.1979, in lab culture, W. Chmielewski coll. (ANIC); 6 ♀♀, 3 ♂♂, Poznan, 14.vi.1973, W. Chmielewski (ANIC).

Comments. Kuzinia Zakhvatkin, 1941, is a small genus of about 8 species of mites usually associated with bees (Delfinado and Baker 1976, Volgin 1978,

Putatunda *et al.* 1984). Most species are known only from the deutonymph (hypopus) stage. The best known species is *K. laevis* (Dujardin), which occurs in the nests of bumble bees in Europe, including *Bombus terrestris* (L.), where it feeds on pollen (Zakhvatkin 1941, Chmielewski 1991). *B. terrestris* first appeared in Australia (Tasmania) in 1992, where it appears to have been accidentally introduced from New Zealand (Semmens *et al.* 1993), and where it now appears to be well established (Semmens 1996). Its commensal mite *Kuzinia laevis* is now recorded from Australia and New Zealand for the first time. It appears that *K. laevis* was accidentally introduced into both Australia and New Zealand from Europe in company with *B. terrestris*.

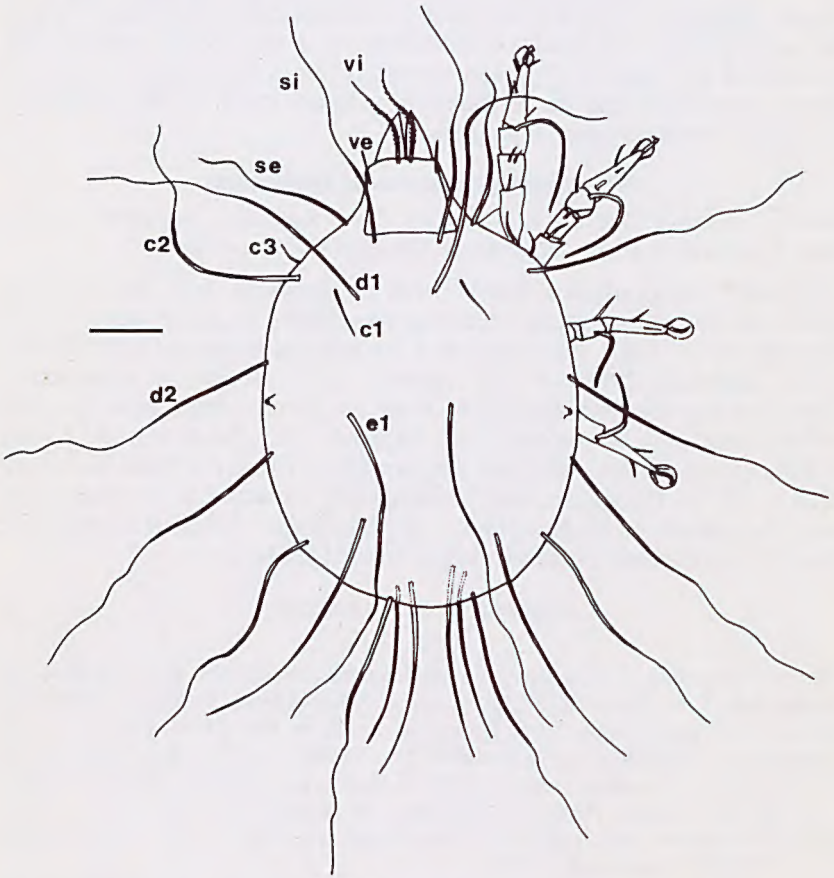


Fig. 1. *Kuzinia laevis*, Tasmania, dorsum of female. Scale bar = 100 μm.

Deutonymphs of *K. laevis* from Tasmania were identified from the descriptions and illustrations of Zakhvatkin (1941) and Delfinado and Baker (1976). The adult female of *Kuzinia* may be distinguished from other genera of Acaridae by its external vertical setae *ve* inserted slightly behind the level of the internal verticals *vi*; internal scapular setae *si* clearly longer then external scapulars *se*; dorsal idiosomal seta *d1* displaced forward close to *c1* and much longer than *c1*; *c1* long enough to reach the base of *d1*; and all dorsal idiosomal setae except *c1* and *c3* greatly elongated (Fig. 1; notation after Griffiths *et al.* 1990). *Kuzinia* is also distinctive in having a longitudinal ridge on the ventral surfaces of tarsi I and II (Fain 1986). Examined specimens of *K. laevis* from Australia and New Zealand were found to be indistinguishable from reference specimens from Poland.

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NEW RECORDS OF DACINAE (DIPTERA: TEPHRITIDAE) FROM NORTHERN QUEENSLAND AND TORRES STRAIT, AUSTRALIA

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Abstract

Bactrocera (Bactrocera) abdonigella (Drew), *B. (B.) abundans* Drew, *B. (B.) curreyi* Drew, *B. (B.) furvilineata* Drew, *B. (B.) lineata* (Perkins), *B. (B.) repanda* Drew, *B. (B.) trifaria* (Drew), *B. (B.) vulgaris* Drew and *B. (Zeugodacus) macrovittata* Drew are newly recorded from Australia (Torres Strait, Queensland). Distributional notes on seven other species in northern Queensland are included. Male lure records are newly provided for *B. (B.) daruensis* Drew [methyl eugenol] and *B. (B.) repanda* [cue lure].

Introduction

Hancock *et al.* (2000) provided an updated list of the distribution and host plants of the 101 species of Dacinae then known from Australia, although a record of *Bactrocera (Bactrocera) daruensis* Drew from Murray Island (Drew 1989) was overlooked. Furthermore, previous records of *B. (B.) pseudodistincta* (Drew) and *B. (B.) redunca* (Drew) are almost certainly based on misidentifications of *B. (B.) furvilineata* Drew and *B. (B.) anfracta* Drew respectively. Continued monitoring of Torres Strait and Cape York Peninsula by the Australian Quarantine and Inspection Service (AQIS) has added a further nine species to the list, all infrequently collected on Torres Strait islands. They are of no economic importance and may be identified using Drew (1989). A total of 109 species is now recorded from Australia. Range extensions are noted also for a further seven species recorded previously from Australia. In addition, an undescribed species, similar in appearance to *B. aurea* (May), is known from Boigu and Saibai Islands in northern Torres Strait.

Voucher specimens from Torres Strait and Cape York Peninsula are lodged in the AQIS Collection, Mareeba. Others are in the Queensland Department of Primary Industries, Cairns.

New Australian records

Bactrocera (Bactrocera) abdonigella (Drew)

Recorded sporadically from Boigu (8 ♂♂, 27.ii.1997, 6.i.2000, 11.xii.2001, 8.i.2002 & 5.iii.2002), Dauan (5 ♂♂, 27.xi.1997, 22.iv.1999, 6.v.1999 & 12.ix.2000), Saibai (11 ♂♂, 11.ii.1998, 26.ii.1998, 22.iv.1999, 2.xii.1999, 6.i.2000, 12.ix.2000, 14.xi.2000, 6.xi.2001, 10.xii.2001 & 5.ii.2002), Dalrymple (3 ♂♂, 6.i.1997 & 20.iv.1999) and Yam (1 ♂, 21.iv.1999) Islands in northern Torres Strait. Previously known only from Papua New Guinea (Drew 1989). Collected at cue lure.

Bactrocera (Bactrocera) abundans Drew

Recorded once each from Boigu (2 ♂♂, 16.xii.1999) and Saibai (1 ♂, 6.i.2000) Islands in northern Torres Strait. Previously known only from Papua New Guinea (Drew 1989). Collected at cue lure.

Bactrocera (Bactrocera) curreyi Drew

Recorded once from Dalrymple Island in northeastern Torres Strait (1 ♂, 14.ix.2000). Previously known only from Papua New Guinea and West Papua [formerly Irian Jaya] (Drew 1989). Collected at cue lure.

Bactrocera (Bactrocera) furvilineata Drew

Recorded sporadically from Saibai (28 ♂♂, 27.xi.1997, 15.i.1998, 11.xi.1998, 14.xi.2000, 9.i.2001 & 6.iii.2001), Boigu (4 ♂♂, 14.xi.2000 & 10.vii.2001) and Dauan (15 ♂♂, 31.x.1996, 25.xi.1996, 27.xi.1997, 10.xii.1997, 19.x.2000, 14.xi.2000 & 7.xii.2000) Islands in northern Torres Strait. Also recorded once from Horn Island in southern Torres Strait (1 ♂, 20.ii.2001). Previous records of *B. (B.) pseudodistincta* (Drew) from the above islands plus Yam in northern Torres Strait (Drew 1989, Hancock *et al.* 2000) appear to be misidentifications of *B. (B.) furvilineata*. Previously known only from Papua New Guinea (Drew 1989). Collected at cue lure.

Bactrocera (Bactrocera) lineata (Perkins)

Recorded once from Dauan Island in northern Torres Strait (1 ♂, 25.ii.2000). Previously known only from Papua New Guinea (Drew 1989). Collected at cue lure.

Bactrocera (Bactrocera) repanda Drew

Recorded sporadically from Dauan (6 ♂♂, 26.viii.1996, 20.xii.1996, 14.i.1997, 6.vi.1997 & 21.ii.2001), Saibai (2 ♂♂, 26.viii.1996 & 19.xii.2000), Boigu (2 ♂♂, 7.i.1999 & 6.v.1999) and Stephen (1 ♂, 16.ii.1999) Islands in northern Torres Strait. Previously known only from Papua New Guinea (Drew 1989). All were collected at cue lure, the first lure record for this species.

Bactrocera (Bactrocera) trifaria (Drew)

Recorded once from Dauan Island in northern Torres Strait (1 ♂, 13.x.1997). Previously known only from New Britain, Papua New Guinea (Drew 1989). Collected at cue lure.

Bactrocera (Bactrocera) vulgaris (Drew)

Recorded once from Warraber (Sue) Island in central Torres Strait (1 ♂, 27.i.1998). Previously known only from Papua New Guinea (Drew 1989). Collected at cue lure.

Bactrocera (Zeugodacus) macrovittata Drew

Recorded twice from Saibai Island in northern Torres Strait (2 ♂♂, 7.xii.2000 & 20.iii.2001). Previously known only from Papua New Guinea (Drew 1989). Collected at cue lure.

Other records

Bactrocera (Bactrocera) batemani Drew

Specimens from the Atherton Tableland and Iron Range (in QDPI Cairns) appear to belong here and extend the range of this species north from Mackay. Collected at methyl eugenol.

Bactrocera (Bactrocera) daruensis Drew

Recorded sporadically from Mer (Murray) Island in eastern Torres Strait (9 ♂♂, 30.xi.1999, 7 & 21.ii.2002) and once from Roma Flats, near Bamaga, Cape York (1 ♂, 18.ii.2002). Previously recorded from Murray I. by Drew (1989) but overlooked by Hancock *et al.* (2000). All were collected at methyl eugenol, the first lure record for this species.

Bactrocera (Bactrocera) recurrens (Hering)

Recorded from Stephen (1 ♂, 3.iii.1999) and Darnley (1 ♂, 20.xii.2000) Islands in northeastern Torres Strait. Previously recorded from Stephen I. by Hancock *et al.* (2000). Collected at cue lure.

Bactrocera (Javadacus) aberrans (Hardy)

A male from Dauan Island (12.x.2001) is the first record for Torres Strait. Collected at cue lure. Previously known from eastern Queensland, as far north as Atherton and Cairns (Drew 1989).

Bactrocera (Sinodacus) salamander (Drew & Hancock)

Recorded from Deliverance Island (2 ♂♂, 26.ii.1999) in northwestern Torres Strait and Thursday Island (2 ♂♂, 4.vi.1998 & 9.ii.2001) in southern Torres Strait. Also recorded from Bamaga, Umagico, Injinoo and New Mapoon, northern Cape York Peninsula (40 ♂♂). Previously known only from Bamaga (Drew 1989). Collected at cue lure.

Dacus (Dacus) secamoneae Drew

A male from Umagico, Cape York has the postpronotal lobe about half yellow and half fuscous, intermediate between Northern Territory specimens and the female from Chillagoe recorded by Drew *et al.* (1999). Males respond weakly to cue lure.

Dacus (Didacus) hardyi Drew

The distribution of this species is extended south from Lockhart River (mid Cape York Peninsula) to Port Douglas and Cairns (specimens in QDPI Cairns). Collected at cue lure.

Acknowledgements

We thank Judy Grimshaw, Kylie Anderson and the Torres Strait staff of the Northern Australia Quarantine Strategy for their contributions to this study.

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BOOK REVIEW

Fauna Malesiana Handbooks, Volume 3. The families of Malesian moths and butterflies, by Jeremy D. Holloway, Geoffrey Kibby and Djunijanti Peggie, with contributions from David J. Carter and Scott E. Miller, and colour plates photographed by Bernard D'Abrera. Published by Brill Academic Publishers, The Netherlands, 2001; xii + 456 pp (with approximately 124 illustrations). ISBN 90 04 11846 2. Price US $145, EUR 118.

To the uninitiated (as I was), Malesia is the extremely complex (entomologically) area stretching from Malaysia to the Solomons, but excluding Australia. The aim of this book (foreword and acknowledgements) is to provide an accessible first guide to the diversity of the Order Lepidoptera found within Malesia. This aim is admirably met, but its appeal extends much further than to students of this zoogeographic area alone.

Chapter 1, defined as the Introduction, pays limited but pertinent depth to the classification and definition of the Lepidoptera. An inclusive section on diversity and biogeography of Malesian Lepidoptera discusses areas of interest – species richness and island areas, endemism and patterns of distribution of higher taxa. Aspects of biology are presented, with references to visual and chemical communication, sound reception and production, and flight and migration. A section on collection and preservation of Lepidoptera material, although admittedly brief, is extremely well presented and extends to making and arranging a collection, genitalic preparation, and concludes with available literature sources on Malesian Lepidoptera. A list is also presented of reference collections in the various countries comprising Malesia.

Chapter 2 addresses the morphology of adults, eggs, larvae and pupae of Lepidoptera to a level that will allow the specialist to proceed to more detailed accounts. To any students of the fauna of this region, this section is extremely well presented and is an invaluable research tool.

Chapter 3 covers the identification of Lepidoptera families. An introduction discusses the complexities and pitfalls in presenting keys to identification of early stages of Lepidoptera, as well as adult stages, especially in such a tropical environment. Family recognition by examination of wing venation, sexing specimens, tympanal organs, head structures and legs, is presented. A brief section on "Quick fixes" and other pertinent cautions adds merit to the work.

This chapter presents a definitive key on families known from, or potentially occurring in the Malesian area. This key in itself is a significant contribution to the book. The identification of larvae is aided in a well presented guide to visible external larval features, feeding or housing restrictions and other biological criteria, such as ant interaction. Host plant specialisation addresses

respective plant groups and families, with a collative account of specialisation of larvae feeding on individual angiosperm families.

Chapter 4 is the major component of the work and presents accounts of all Malesian Lepidoptera families. It is a superb presentation, based on the authors' collective knowledge, and details some 178 pages of family analyses. Eight well presented colour plates are good value.

A number of appendices then present comparison of species totals of various lepidoptera groups in various regions, as well as a breakdown of number of recorded species for Sphingidae and butterfly families in various parts of Malesia. Appendix 4 presents data of pest species recorded from Malesia. Appendix 5 presents a table of taxonomic and nomenclatural changes in microlepidoptera presented in this handbook. An extensive list of reference works utilised in the completion of this handbook demonstrates the depth of dedication shown by the authors. An index to morphological and cladistic terms precedes the index to lepidoptera names.

In summation, this handbook is extremely well presented, authoritative, and will offer appeal to both amateur and professional entomologist alike. Its appeal will also extend to anyone with an interest extending beyond the Malesian area. From a personal level, I received much satisfaction in randomly selecting one or two north Queensland moth specimens and adequately keying their family classification, with considerable certainty. While not the intention of this handbook, it clearly demonstrated the extended potential and quality that the authors have achieved.

David Lane

MATING BEHAVIOUR OF GREYBACK AND GRATA CANE BEETLES, *DERMOLEPIDA ALBOHIRTUM* (WATERHOUSE) AND *LEPIDIOTA GRATA* BLACKBURN (COLEOPTERA: SCARABAEIDAE)

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Abstract

Mating behaviour of greyback cane beetle, *Dermolepida albohirtum* (Waterhouse) and grata cane beetle, *Lepidiota grata* Blackburn, is described and compared. Mating pairs of *D. albohirtum* were observed within feeding aggregations in *Ficus opposita* and *Acacia* spp. during 4 hours from late afternoon to early evening. Copulation by *D. albohirtum* lasted on average 12 minutes and was preceded by the male resting piggy-back on the female and vibrating her body. Mating by *L. grata* occurred during a 30 minute period in trees at dusk. Females of *L. grata* called by repeatedly extending and retracting their ovipositor. Males appeared shortly after, flying upwind. Copulation followed immediately a male mounted a female, and lasted on average 18 minutes. Any sex pheromone produced by *D. albohirtum* may be active over a distance of less than 1 m, and may not be useful for monitoring numbers. By comparison, the mating behaviour of *L. grata* is consistent with a sex pheromone that acts over longer distances.

Introduction

Greyback canegrub, *Dermolepida albohirtum* (Waterhouse), is the most important insect pest of sugarcane in northern Queensland from Mossman (16°21'S, 145°15'E) to Sarina (21°22'S, 149°13'E). Since the mid-1990s, it has been in outbreak numbers in the Burdekin region, centred on Ayr (19°34'S, 147°24'E). It has an annual lifecycle, spent mainly as larvae in free-draining soils. In the Burdekin, beetles can be observed in favoured feeding trees (*Ficus* spp., *Corymbia tesselaris*, *Acacia* spp. and palms) between October and January. Beetles fly and feed during the evening and night and some beetles are also present during the day, resting in feeding trees.

Grata canegrub, *Lepidiota grata* Blackburn, is an occasional pest of sugarcane in northern and central Queensland from Ingham (18°43'S, 146°10'E) to Gin Gin (25°00'S, 151°58'E). Its life cycle is 1 or 2 years depending on field conditions (Chandler and Chapman 1989). Each year in the Burdekin, adults fly and feed in eucalypts, particularly *Eucalyptus tereticornis*, during the evening and night during late spring and summer.

Many scarabs use pheromones to facilitate mate location (Leal 1998). Allsopp (1993) showed that unmated females of the canegrubs *Antitrogus consanguineus* (Blackburn), *A. parvulus* Britton and *Lepidiota picticollis* Lea probably use pheromones to attract males. The identification and isolation of pheromones may provide the basis for monitoring and management tools for cane beetles. Collection, isolation and field-testing of putative pheromones of cane beetles are aided by an understanding of their mating behaviour. Knowledge of the mating behaviour of *D. albohirtum* and

L. grata is limited. Mating by *D. albohirtum* has been observed during a 1 hour period in the evening in trees up to 5-7 m above ground (Illingworth and Dodd 1921, Jarvis 1933). Illingworth and Dodd (1921) observed swarming by *L. grata* at dusk followed by mating on vegetation from near ground level up to 10 m above ground and copulation for one pair of *L. grata* took 35 minutes. Here we describe in more detail the mating behaviour of *L. grata* and *D. albohirtum*.

Materials and Methods

The daily pattern of mating for *D. albohirtum* was determined by counting mating pairs at four sites in the Burdekin for observation periods of 1.5 to 23.5 hours (Table 1). At site 1, pairs were counted at 15 minute intervals. A thunderstorm prematurely ended counting and beetles were collected to estimate the proportion of mated and non-mated beetles and males and females in the feeding aggregation. A count of all beetles was made at sites 2-4 during the evening. Beetles were collected at site 2 on the day following the observation of mating and were sexed. Two-by-two contingency tables were used to test whether the sex ratio of beetles in the aggregation was different to unity at sites 1 and 2. At site 4, the number of males resting on the back of females (piggy-back pairs), a stage preceding copulation, was counted every 30 minutes.

Table 1. Site description and period of observation for feeding aggregations of *D. albohirtum* in which mating was observed in our study. The proportion of *D. albohirtum* observed mating was based on an estimate of the number of beetles at each site after no further mating was observed.

Site	Site description	Date and period of observation	Pairs	Proportion of beetles mating in aggregation
1	Outer row of cane field, Burdekin Sugar Experiment Station	19 Nov 1999 1700 – 1830	32	0.06
2	1 tree (*Ficus opposita*), Burdekin River bank	17-18 Nov 2000 1515 – 0715	41	0.04
3	6 trees (1 *Acacia cincinnata*, 4 *A. mangium*, 1 *F. opposita*), Ayr golf course	1-2 Dec 2000 1500 – 0130	40	0.08
4	7 trees (*F. opposita*), Haughton River bank	8-9 Dec 2000 0900 – 0830	29	0.06

As adult *L. grata* are crepuscular and nocturnal, mating pairs and individuals were counted during the late afternoon and evening. Pairs and individuals were counted on a group of three small (< 3m tall) trees (*Eucalyptus tereticornis*, *Acacia cincinnata* and *Nauclea orientalis*) on the Ayr golf course from 1830 to 2100 hours on 22 January 2001. Counts were made for five consecutive 15 minute intervals and then after 30 minutes and one hour. Other occasional observations of *L. grata* behaviour were made between 2100 and 0100 hours and later in the morning from 0700 to 0800 hours.

Females of both species (n = 35) were collected in copula, frozen and dissected to determine ovarian status as an approximate estimate of age. Females of *D. albohirtum* emerge with no ovarian development and must feed for one to two weeks before oocytes are fully grown (D. Logan, unpubl. obs.). Ovarian status at emergence by *L. grata* is not known. Development of ovaries was scored as either with no fully grown oocytes or with some or all oocytes fully grown. As feeding may be necessary before females can produce pheromones, the hindgut of females was examined for evidence of ingested plant matter.

Duration of copulation was determined with stop-watches for 15 pairs of *D. albohirtum* and for 18 pairs of *L. grata*. Copulation times for *D. albohirtum* and *L. grata* was compared by two-sample t test at $P < 0.05$. Pre-copulatory behaviour was timed for seven pairs of *D. albohirtum*.

Results and Discussion

Mating behaviour of D. albohirtum

Mating by *D. albohirtum* occurred during 4 hours from the late afternoon to early evening (Fig. 1), much longer than the 1 hour period found by Illingworth and Dodd (1921). No swarming by males was observed. Instead, mating by *D. albohirtum* occurred amongst aggregations of feeding beetles. Mating pairs were observed hanging from leaves or branches from < 0.5 m to 4 m above the ground. We observed pre-copulatory behaviour that involved a male resting piggy-back on a female for up to two hours (Fig. 2a) and often vibrating his body and hers. Vibration occurred without leverage from adjacent branches or leaves. Between and during vibration events, the male was often perched forward on the female with antennal club segments fanned and may have been palpating the female's head. The male extended his aedeagus (Fig 2b) before successful intromission took place (Fig. 2c). The male remained in this position (Fig. 2c) relatively briefly (mean time in minutes $\pm$ SD = 2.51 $\pm$ 0.79, n = 7, range = 1.66 – 3.90) prior to leaning back and hanging upside down (Fig. 2d) often held only by the aedeagus. On average, males remained hanging upside down for 12.04 minutes (SD = 3.29, n = 15, range = 6.03 – 16.53). Some unsuccessful pairings were observed in which the piggy-back male vibrated the female and extended and retracted his aedeagus one or more times, but never achieved intromission. At site 4, the number of piggy-back pairs increased in the afternoon prior to the formation of mating pairs (Fig. 2d). Some pairs remained as piggy-back pairs for at least two hours before mating or moving apart. One piggy-back pair at site 4 mated at 1730 hours after being first observed at 1100 hours and marked with liquid paper. Within aggregations of *D. albohirtum*, there were few occasions when any movement to form pairs was seen. This was generally a flight of less than 1 m by a male to a female. Thus, any sex pheromones released by females of *D. albohirtum* may be most active over short distances.

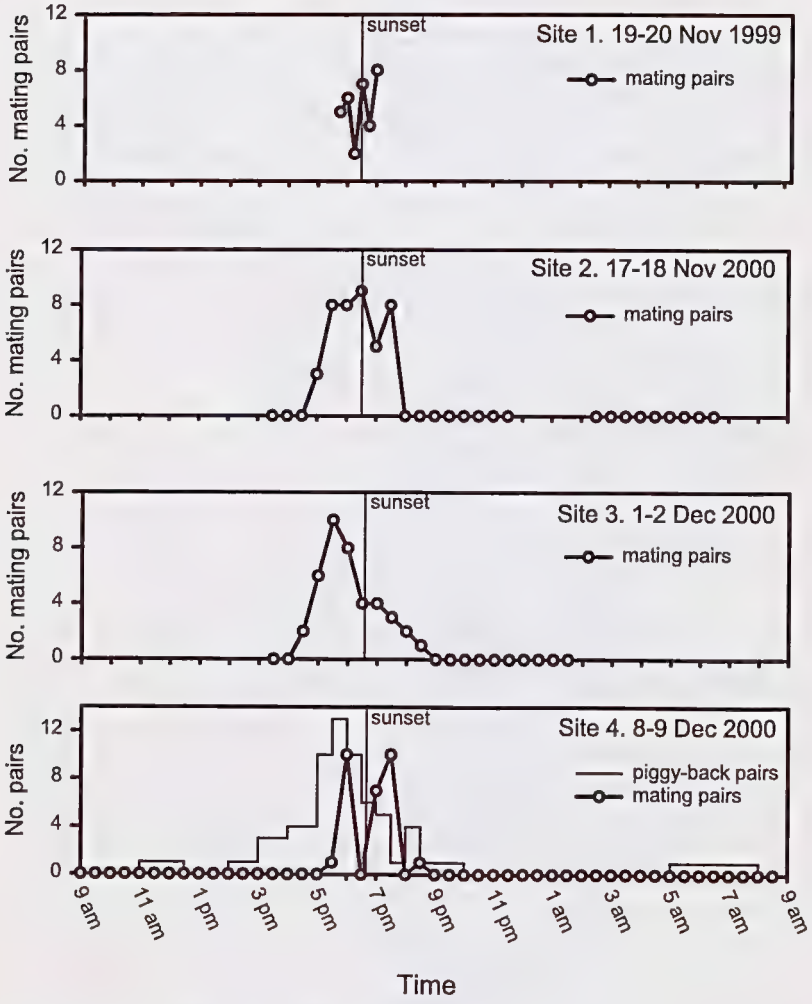


Fig. 1. Time of mating for *D. albohirtum* at four sites in the Burdekin.

Most females (80%) collected during mating had food in their hindguts, consistent with being part of a feeding aggregation. Most mated females (66%) had no fully developed oocytes indicating they may have recently emerged. The sex ratio of beetles in the aggregation at site 1 was unity (two by two contingency test, $\chi^2 = 0.11$, P = 0.74, n = 166) and at site 2 was female-biased ($\chi^2 = 4.87$, P = 0.03, n = 159, 62% females). A very small proportion of beetles in feeding aggregations mated at each site on any one night (Table 1).

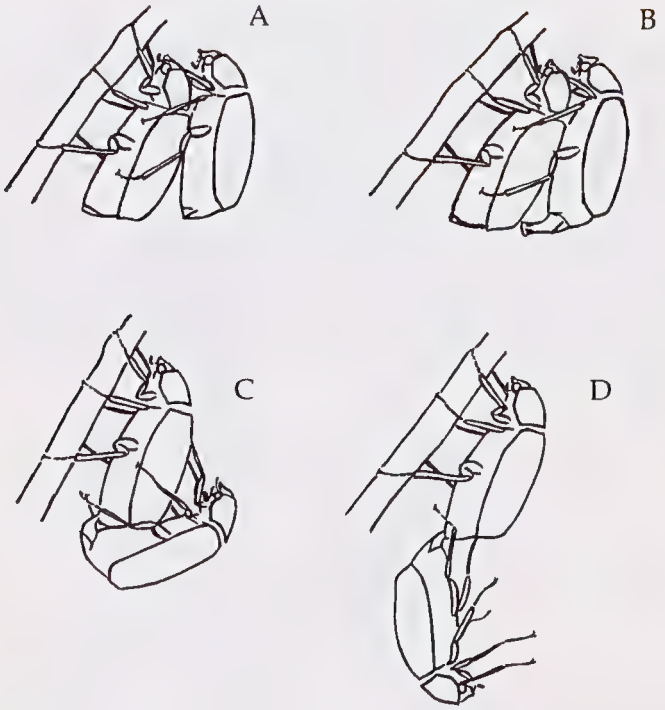


Fig. 2. Sequence of mating behaviour for *D. albohirtum*. (A) Male *D. albohirtum* crawls onto the back of female and vibrates female; (B) Male extends aedeagus and (C) intromits; (D) After several minutes, male hangs backwards and remains in this position for 6-16 minutes.

Mating behaviour of L. grata

Mate location by male *L. grata* was consistent with the release of pheromones by females. Beetles of *L. grata* appeared in flight shortly after sunset. Females landed usually at least 1 m above ground level on tree trunks, branches and leaves of a variety of trees and shrubs including *Eucalyptus* spp., *Acacia* spp., and *Melaleuca* spp. Females began 'calling' immediately by repeatedly extending and retracting their ovipositor (Fig. 3). One or more males often arrived within a minute, flying upwind, landed on the female or near her and crawled onto her back. The male immediately inserted his aedeagus and fell back to hang upside down, as with *D. albohirtum* (Fig. 2d). There was no pre-copulatory behaviour as with *D. albohirtum*. After insertion of the aedeagus, other males on and near the mating pair or circling nearby

quickly dispersed. Mating took on average 18.08 minutes (SD = 3.19, n = 18, range = 9.82 – 25.37), significantly longer than for *D. albohirtum* (T = 5.35, df = 31, P < 0.0001), but shorter than the 35 minutes recorded for one pair by Illingworth and Dodd (1921). If the male was not immediately successful in mating, other males attempted to copulate with either the female or the initial male, if he remained on her back. Many females called from the same tree or shrub and a swarm of males was present during the 10 to 15 minute period when mating pairs formed. No pairs remained 30 minutes after swarming started (Fig. 4). Males often flew away immediately, but females tended to remain longer. Mating pairs were only observed during 30 minutes at dusk (Fig. 4). After mating, beetles were seen feeding on trees (especially *Eucalyptus tereticornis*) (Fig. 4) until at least 0100 hours. No beetles were present after 0700 hours, probably having returned to the soil where they spend the day.

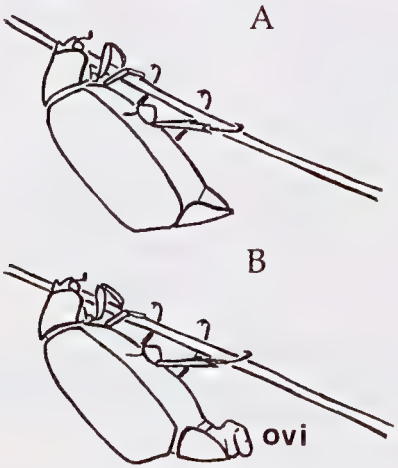


Fig. 3. Behaviour of female *L. grata* immediately prior to mating. (A) Female lands on branch and (B) starts to repeatedly extrude and retract her ovipositor (ovi).

In contrast to mated females of *D. albohirtum*, most females (91%) of *L. grata* collected while mating, had not fed. Most females (77%) had some or all of their oocytes fully grown. Feeding may not be necessary to develop oocytes or for the production of pheromones in *L. grata*. Females of *L. negatoria* Blackburn emerging from the soil for the first time have some of their oocytes fully grown and often mate on the same night (Logan 2000). Females of *L. grata* may have a similar behaviour, mating on their first night of emergence.

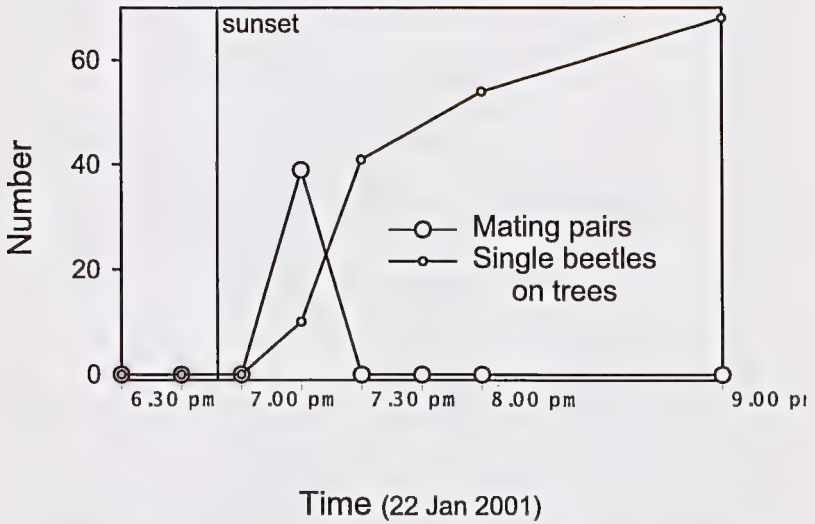


Fig. 4. Time of mating for *L. grata* and number of beetles feeding in a group of three trees at one site in the Burdekin.

Comparison of mating behaviour

Mating behaviour of *L. grata* is similar to that of the cane beetles *Lepidiota* spp. and *A. parvulus* (Illingworth and Dodd 1921, Logan 2000, K. Chandler, pers. comm.). Males of *Lepidiota* spp. and *A. parvulus* swarm around a female prior to mating and are probably attracted by a pheromone (Allsopp 1993). Swarming and mating occurs during 30 minutes at dusk.

Mating behaviour in *D. albohirtum* is unusual in comparison with other cane beetles. Copulation is more rapid than for *L. grata*, *L. negatoria* (about 20 minutes: Logan 2000) and *L. frenchi* Blackburn (20-29 minutes: Illingworth and Dodd 1921). Mating may occur sometime during a four hour period from the late afternoon to early evening, rather than during the brief period following the evening emergence of other cane beetles. Many females of *D. albohirtum* have fed prior to mating; as far as is known, other cane beetles mate before feeding (Logan 2000). The tendency for *D. albohirtum* to form piggy-back pairs is unknown for other cane beetles. However, piggy-back pairs occur in feeding aggregations of the rutelines *Anoplognathus porosus* (Dalman), *A. boisduvalii* Boisduval and *Popillia japonica* Newman, which remain as pairs for up to two hours after copulation (Barrows and Gordh 1978). Mounting in *D. albohirtum* precedes mating and may be prompted by a sex pheromone released by females.

Aggregation in feeding trees by *D. albohirtum* may be due to plant volatiles released from leaves during feeding. The forest cockchafer *Melolontha hippocastani* F. was attracted to mechanically damaged leaves of two favoured feeding trees and a non-host tree and a synthetic mix of green leaf volatiles (Ruther *et al.* 2000). Male *M. hippocastani* were also attracted to extracts washed from unmated females. Ruther *et al.* (2000) concluded that males used volatiles released from leaves damaged during feeding as well as volatiles released from females in order to facilitate mate location. Males of *D. albohirtum* may use a similar mechanism to locate females. Sex pheromones or other sex-specific volatiles from females may have a limited range and thus are unlikely to be useful for monitoring numbers of *D. albohirtum*. By comparison, females of *L. grata* release a pheromone that is active over a relatively wide area and may be useful for monitoring or trapping beetles.

Acknowledgements

Staff at the Queensland Herbarium identified the species of *Acacia* at the Ayr golf course on which *D. albohirtum* were feeding and mating. Sunset times for Ayr were from the website of the Australian Surveying and Land information group, Department of Industry, Science and Resources (www.auslig.gov.au). Peter Allsopp made some useful comments on the draft manuscript.

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FIRST RECORDS FOR THE PAPERBARK CICADA *CICADETTA HACKERI* (DISTANT) AND *CICADETTA SPINOSA* (GODING & FROGGATT) (HEMIPTERA: CICADIDAE) FROM SYDNEY, NEW SOUTH WALES

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Abstract

Cicadetta hackeri (Distant) and *Cicadetta spinosa* (Goding & Froggatt) have been captured for the first time in the Sydney metropolitan area. *C. hackeri* is well-established but very localised, suggesting introduction, whereas evidence suggests that *C. spinosa* may have been resident in western Sydney for some decades.

Introduction

The paperbark cicada, *Cicadetta hackeri* (Distant), has been recorded from Bundaberg in southeastern Queensland to Port Stevens on the New South Wales north coast (Moulds 1990). Throughout its range, it inhabits paperbark or coastal teatree (*Melaleuca quinquenervia*), usually close to the coastline (Moulds 1990). In contrast, *Cicadetta spinosa* (Goding & Froggatt) has an inland distribution, with records from the Roma, Rolleston and Chinchilla regions of southern Queensland, through the Inverell, Narrabri and Nandewar Range areas of inland northern New South Wales, to Hay and northwestern Victoria (Moulds 1990). Adults are usually located high in eucalypts, especially ironbarks (J. Moss, pers. comm.).

Sydney records

One singing *C. hackeri* was netted on 4 Nov 2000 (Fig. 1) from a large paperbark bordering the roadway adjacent to the Killara golf course. A total of 58 exuviae were also collected: 36 of these had the darkened abdominal rings typical of *C. hackeri*, while the remainder were lighter and typical of *Cicadetta celis* Moulds. After dusk on 11 Nov 2000, twelve cicadas emerging on several paperbarks at the same location in Killara were collected and held individually with exuviae. Seven were *C. hackeri* (3 ♂♂, 4 ♀♀) and five were *C. celis* (2 ♂♂, 3 ♀♀); exuviae matched the identity of the specimens.

On 11 Nov 2000, the rather strange "creaking" sound of *C. spinosa* was heard twice only at a site along Luddenham Rd, St. Marys (J. Moss and S. Emery, pers. obs.). On 19 Jan 2001, eight cicadas were observed emitting the same sound at heights of 8-10 m in ironbark trees (*Eucalyptus fibrosa* and *E. siderophloia*) amongst bushland close to the suburb of Llandilo in western Sydney. Three males were captured in adjacent paperbarks on 24 Jan 2001 (Fig. 2), matching the photographs and descriptions in Moulds (1990). Unfortunately, subsequent heavy rain obliterated the cohort. During later visits to the location between 4-10 Feb 2001, two *Urabunana daemeli* Distant (1 ♂, 1 ♀; S. Emery) (Fig. 3) and three *U. verna* Distant (3 ♂♂; S. Emery) (Fig. 4) were taken: recent records for both are rare in the Sydney region.



Figs 1-4. (1) *Cicadetta hackeri*; (2) *C. spinosa*; (3) *Urabunana daemeli*; (4) *U. verna*. Scale: (1) 2 x natural size; (2) 1.5 x natural size; (3-4) 2.5 x natural size.

Discussion

Considering the limited distribution of both *C. hackeri* and *Melaleuca quinquenervia* around the streets bordering the Killara golf course, it is possible that the cicada was introduced as eggs or larvae with host plants. The population is well established as evidenced by the quantity of exuviae and readily coexists with *C. celis* on the same host trees. While the population of *C. hackeri* appears geographically isolated by the extent of the paperbarks, *C. celis* is widespread in *Melaleuca* and *Leptospermum* trees and shrubs in the Sydney region. This record from Killara extends the distribution of *C. hackeri* around 150 km further south from its previous limit at Port Stevens.

Given the large numbers of *C. spinosa* and its presumptive presence at St Marys and Llandilo (*ca* 20 km linear distance apart), it is also highly likely that this species has been present in the region for some time. Both a visual sighting and song identification of this species occurred on 24 Dec 1982 at McGrath's Hill, close to the current location, but a specimen was not captured (J. Moss, pers. comm.). Additional evidence that the population of *C. spinosa* has remained undetected since 1982 is provided by the capture of both *U. daemeli* and *U. verna* at the same location. These species also have no records from the Sydney region for over two decades; the most recent records were at Hornsby Heights (1 ♂, 10 Jan 1970; 2 ♂♂, 25 Nov 1971, J. Moss) and Terrey Hills (1 ♂, 7 Dec 1997, N. Emery) (*U. daemeli*) and in the Casula-Blacktown area (2 ♂♂, 2 ♀♀, 10 Jan 1970, J. Moss) (*U. verna*). As well as providing the first specimens of *C. spinosa* from the Sydney region, the records are the first recorded east of the Great Dividing Range in New South Wales for this species (see Moulds 1990). An additional six specimens (5 ♂♂, 1 ♀) were captured by the authors at the same location between 18 Jan and 2 Feb 2002.

Acknowledgements

We thank Dr J. St-Leger Moss for records of *C. spinosa* and *Urabunana* species in Sydney and David McClenaghan and Kate Smith, CSIRO Entomology, for assistance with photography.

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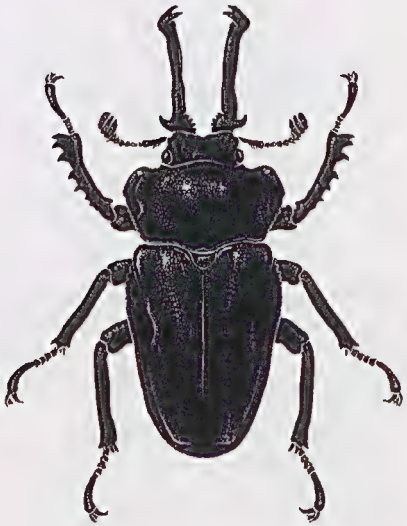
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